

# Surge Arresters

**UltraSIL™ Housed VariSTAR® UHS  
Surge Arrester for Systems through 72 kV  
IEC 10-kA; Line Discharge Class 1**

Electrical Apparatus  
**1235-91**

## GENERAL

VariSTAR® UHS Surge Arresters offer the latest in metal oxide varistor (MOV) technology for the economical protection of medium-voltage class power and substation equipment. These arresters are gapless and are constructed of a single series column of 26 mm diameter MOV disks. The arrester is designed and tested to the requirements of the International Electrotechnical Commission Standard IEC 60099-4 (IEC 99-4), and is available in ratings suitable for the transient overvoltage protection of electrical equipment on systems through 72 kV.

The UltraSIL™ housed UHS surge arrester incorporates the industry recognized superior polymeric material – Silicone Rubber.

The advantages of polymer-housed arresters – reduced size and weight, and enhanced safety – have been refined in this new generation of surge arresters: the UltraSIL housed UHS surge arrester from Cooper Power Systems.

Our Quality Program is registered in conformance with ISO 9001.

## CONSTRUCTION

Construction of the UltraSIL housed Class 1 surge arrester begins with Metal Oxide Varistor's (MOV's) produced at our dedicated disk manufacturing facility in Olean, NY USA. Using MOVs having excellent electrical properties, these arresters provide superior overvoltage protection for MV substations. Manufacturing our own MOV disks allows strict quality control over the manufacturing process from start to finish.

VariSTAR arresters incorporate a simple MOV disk stack combined with end electrodes. This assembly is coated with fiberglass-reinforced epoxy using an automated fluidized bed process. It is cured to form a rigid mechanically strong module capable of withstanding electrical, environmental, and cantilever loading conditions.

The UltraSIL housing is then fit and bonded to the module to form a solid, high dielectric strength, insulation system.

Following assembly, each arrester is subjected to a battery of routine electrical tests to ensure the highest service performance.

## FEATURES

The UltraSIL silicone rubber housing was chosen for its superior insulation performance when compared to other polymeric housing materials. Long term environmental testing has verified the lifetime superiority of UltraSIL silicone rubber when compared to other polymeric insulating materials.

Independent laboratory tests have verified the superiority of silicone rubber in terms of hydrophobicity, resistance to UV and surface tracking performance in contaminated environments, chemical inertness, temperature stability and other key insulating properties.

UltraSIL silicone rubber will not support biological growth (algae and mildew) and is non-flammable.

UltraSIL arrester can be customized with a variety of different terminal and mounting options. Applications requiring extra leakage distance can easily be accommodated within the catalog numbering system; see page 6.

## OPERATION

The operation of the VariSTAR arrester is typical of gapless metal oxide arrester. During steady state conditions, line-to-ground voltage is continuously across the arrester terminals. When overvoltages occur, the VariSTAR arrester immediately limits the overvoltage to the required protective level by conducting only the necessary level

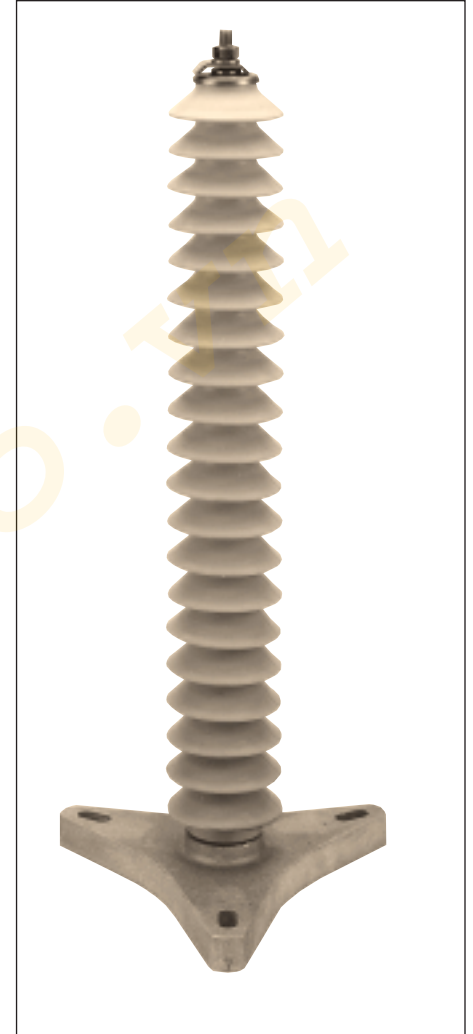
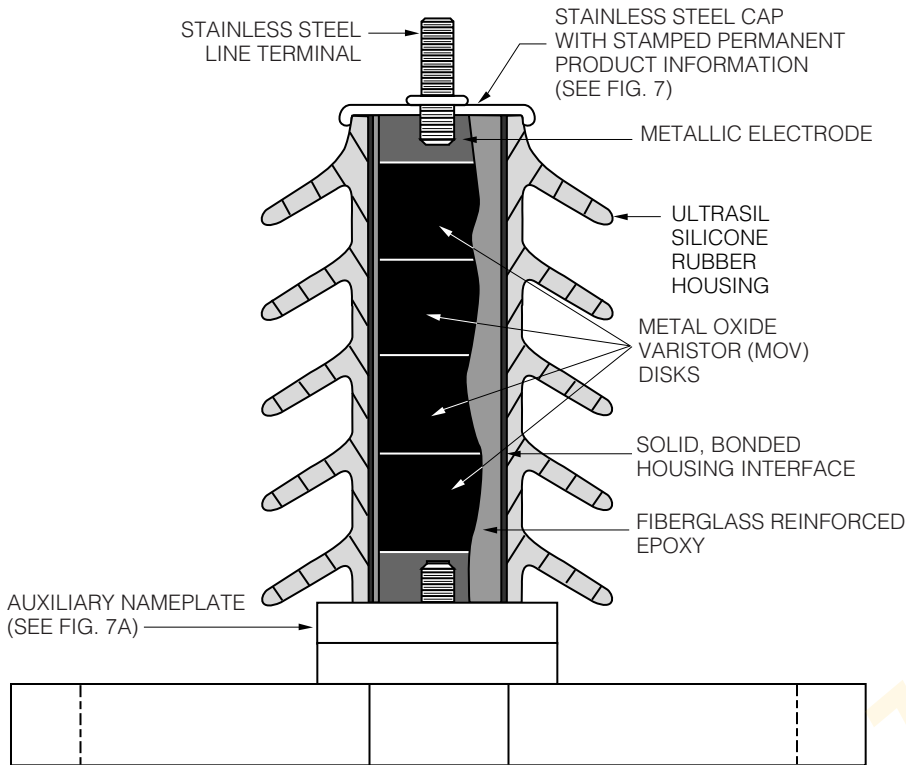


Figure 1.  
60 kV UltraSIL Class 1 Arrester.

Arrester Type	UHS
System Application Voltages	3-36 kV
Rated Arrester Voltages, $U_r$	3-36 kV
Power System Frequency	50-60 Hz
Applicable Design and Test Standard	IEC 60099-4
Nominal Discharge Current	10 kA
Line Discharge Class	1
High Current Withstand	100 kA
Pressure Relief Class	20 kA (rms Sym.) (B)
Maximum Energy, Square Wave (Repeatable 1 min)	2.85 kJ/kV of $U_c$
High Current, Short Duration Energy Handling	(100kA) 3.9 kJ/kV of $U_c$



**Figure 2.** Cutaway illustration of 10 kV UltraSIL Housed VariSTAR Class 1 Arrester.

of surge current to earth. Upon passage of the over-voltage condition, the arrester returns to its initial condition once again, conducting only minimal leakage current.

UltraSIL housed VariSTAR Class 1 arresters are ideal for the protection of substation apparatus in areas of moderate lightning incidence and for protection against switching surges generated on transmission systems.

Extensive pressure relief test have been conducted in accordance with IEC 60099-4 (IEC 99-4) to demonstrate the UltraSIL housed VariSTAR Class 1 arrester's ability to withstand fault currents for specific durations. The following table shows the level to which the arrester is non-fragmenting.

**Table 1**  
Pressure Relief Tests  
(Fault Current Withstand)

Arrester Type	IEC Pressure Relief Class	Fault Current Amplitude (kA rms) Sym..	Minimum Fault Current Duration (seconds)
UHS	B	0.8 20	0.5 0.2

### DESIGN TESTING

The housing material, internal components and hardware work as a system and stand up to years of exposure to environmental extremes. To assure a superior level of performance, the components and the assembled arrester unit have been subjected to a testing program that accurately simulates years of exposure to field conditions. Tests include:

IEC 60099-4 (IEC 99-4) Testing – Full Certification to performance requirements by an independent laboratory has been completed. A certified test report is available.

Additional design verification of the UltraSIL housed VariSTAR Class 1 arrester includes testing for:

- Ultraviolet Withstand
- High Voltage Dielectric integrity
- Wet Arc Tracking Resistance
- Thermal Shock
- Coefficients of Expansion and Materials Compatibility
- Cantilever Strength
- Terminal Torque

This is only a partial listing of the comprehensive design test performed on the UltraSIL housed VariSTAR Class 1 Arrester. For detailed reports please contact your Cooper Power Systems sales representative.

### ROUTINE TESTS

A complete automated production test program ensures a quality product. Each metal oxide varistor receives a series of electrical test. Quality is further demonstrated by tests performed to destruction on samples from every lot of varistors.

Listed are the VariSTAR tests on disks performed in accordance with IEC 60099-4 (IEC 99-4):

- 100% Physical Inspection
- 100% Residual Voltage Test
- 100% V1mA/cm<sup>2</sup> (voltage when 20mA DC is applied)
- 100% Watts Loss at 1/05 x U<sub>c</sub> measured at ambient temp.
- 100% Transmission Line Discharge Energy Test
- Lot High Current, Short Duration
- Lot Thermal Stability Test
- Lot Aging Test

Each fully assembled UltraSIL VariSTAR Class 1 arrester must pass the following routine tests per IEC 60099-4 (IEC 99-4), 1991.

- Physical Inspection
- Partial Discharge Test
- Reference Voltage Test
- Leakage Current Test

### GENERAL APPLICATION RECOMMENDATIONS

The rating of an arrester is the maximum power-frequency line-to-ground voltage at which the arrester is designed to pass the IEC operating duty test. Table 2 provides a general guide for the selection of the proper arrester for a given system voltage. Cooper Power Systems application engineers are available to make specific system application recommendations.

## SELECTION OF ARRESTER RATING

In the arrester rating selection it is prefer-able to determine the lowest arrester rating that will ensure satisfactory operation. This is the optimum solution because the arrester selected will not only provide the greatest margin of insulation protection but also be the most economical choice.

Increasing the arrester ratings above the minimum increases the likelihood of arrester survival during potential system contingencies but compromises the protection of equipment insulation. Table 2 lists VariSTAR UHS arrester ratings commonly used on various 3-phase systems.

Rating selection should begin with consideration of the maximum system operating voltage. The maximum power frequency voltage expected under normal system conditions (expressed line-to-earth) should not exceed the selected arrester's continuous operating voltage ( $U_c$ ).

The temporary overvoltage (TOV) capability of the VariSTAR UHS arrester is shown in Figure 3. The curves indicate the arrester's ability to withstand abnormal system power frequency (sinusoidal) overvoltages for various durations. The values shown assume that the arrester has been energized at COV ( $U_c$ ) prior to an overvoltage event, that the arrester is in an ambient temperature of 60° C, and that after the overvoltage durations shown, demonstrate that the arrester will thermally recover when once again energized at COV ( $U_c$ ).

The voltage withstand capability for application on ungrounded systems after IEC high-current duty is 1.09 per unit of COV ( $U_c$ ) for 24 hours. For ungrounded systems, systems utilizing high impedance or resonant grounding and other systems where the line-to-earth voltages exceed this stated TOV capability, arresters having a COV ( $U_c$ ) equal to line-to-line voltage may be required.

For non-sinusoidal transient voltages caused by system switching operations a transient network analyzer (TNA) study is recommended; Cooper Power Systems engineers are available to make these studies.

Figure 3 also illustrates the arrester's TOV capabilities with and without prior switching surge duties of up to a maximum capability of 2.85 kJ/kV of COV ( $U_c$ ).

**Table 2**  
Arrester Ratings Commonly Used on 3-Phase Systems

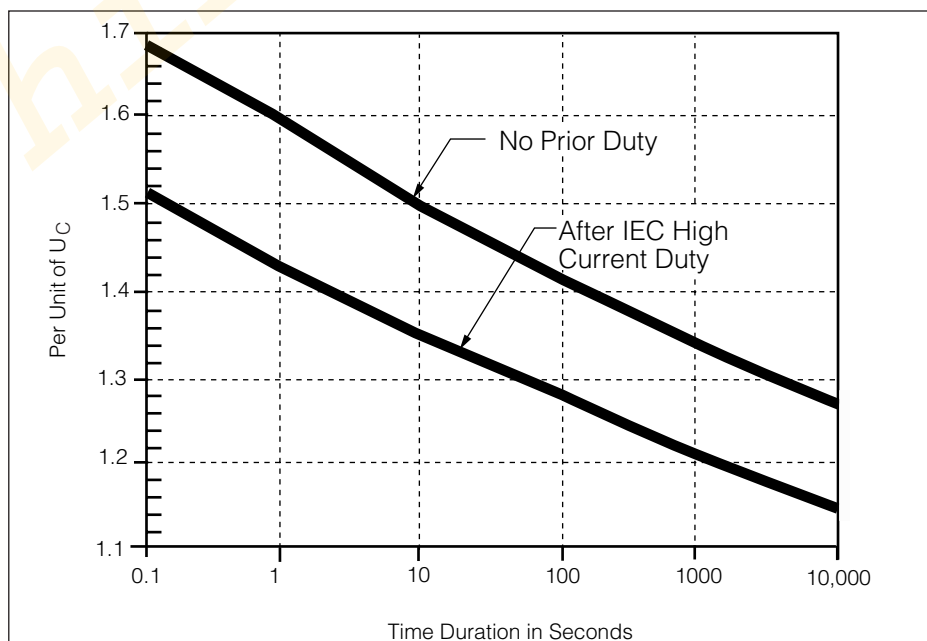
System Voltages L-L (kV)		Arrester Ratings (kV)	
Nominal	Maximum	Grounded Circuits	High-Impedance/ Ungrounded Circuits
3.3	3.7	3	6
6.6	7.3	6	9
10.0	11.5	9	12-15
11.0	12.0	9-10	12-15
16.4	18.0	15.0	18-21
22.0	24.0	18-21	24-27
33.0	36.3	27-30	36-39
47.0	52.0	39-48	54-60
66.0	72.0	54-60	-

To assure proper application, the following information is normally required:

1. Maximum system operating voltage.
2. System grounding conditions.
  - A. For four-wire circuits, grounding conditions depend upon whether the system is multi-grounded, whether it has neutral impedance, and whether common primary and secondary neutrals are used.
  - B. For three-wire circuits, grounding conditions depend upon whether the system is solidly grounded at the source, grounded through the neutral impedance at the source, grounded through transformers, or ungrounded.

Where unusual conditions exist (high ground resistance, high capacitive load, unusual switching surge duty, etc.), the following supplementary information is required:

- Type of unusual condition.
- BIL of equipment and separation distance to protected equipment.
- Type of construction (phase spacing, length of line, conductor size, etc.).
- Grounding and phase-sequence components of source impedances.
- Phase-sequence components of load impedances.
- Available fault current.
- Potential for loss of neutral earthing during system events.



**Figure 3.**  
Temporary Overvoltage Capability of VariSTAR UHS Surge Arresters.

Note: The 24 hour TOV with prior duty is 1.09 per unit of  $U_c$ .

## PERFORMANCE AND PROTECTIVE CHARACTERISTICS

Table 4, “Protective Characteristics of the UltraSIL Housed Class 1 Surge Arrester” displays the Arrester Rating ( $U_r$ ), Continuous Operating Voltage ( $U_c$ ) and the guaranteed protective characteristics.

The Steep Current Impulse protective level is the maximum residual voltage for an impulse current cresting in one microsecond. Lightning Impulse Residual Voltages represent the maximum protective levels exhibited by the arrester when discharging lightning currents of the standard 8/20 microsecond waveshape. The maximum Switching Impulse Residual Voltages are based on a switching surge current having a time to crest of 30 microseconds. For all ratings the switching surge energy absorption capability is 2.85 kJ/kV of  $U_c$  (repeatable in one minute).

**TABLE 3**  
Insulation Withstand Voltages

Housing Designation	Housing Leakage Distance (mm)	Strike (mm)	Insulation Withstand Voltages	
			BIL 1.2/50 Impulse (kV, Pk)	Wet 50/60 Hz 60 seconds (kV, rms)
03	183	79	70	23
04	256	106	82	33
05	330	133	90	45
06	404	159	97	55
07	477	186	107	66
08	551	213	118	78
09	625	239	129	89
10	698	266	140	99
11	772	293	152	109
12	846	320	164	119
13	919	346	177	128
14	993	373	190	137
15	1067	400	204	146
16	1140	426	218	154
17	1214	453	233	162
18	1288	480	248	169
19	1361	506	264	176
20	1435	533	280	183
21	1509	560	296	189

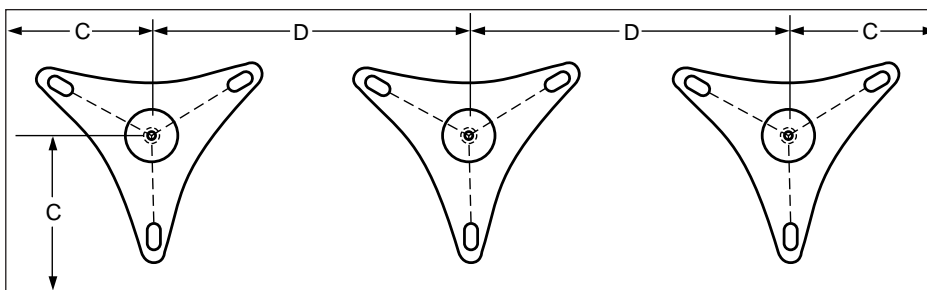
**TABLE 4**  
Protective Characteristics of the UltraSIL Housed VariSTAR UHS Surge Arrester

Arrester Rating $U_r$ (kV, rms)	Arrester MCOV $U_c$ (kV, rms)	Steep Current Residual Voltage (kV crest)	Lightning Impulse Residual Voltage (kV Crest) 8/20 $\mu$ s Current Wave						Switching Impulse Residual Voltage (kV Crest) 30/60 Current Wave	
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	125 A	500 A
3	2.55	11.3	8.6	9.1	9.5	10.4	11.5	13.0	7.4	7.9
6	5.10	22.6	17.2	18.2	19.1	20.8	23.0	25.9	14.8	15.9
9	7.65	32.6	24.8	26.3	27.5	30.0	33.2	37.4	21.4	22.9
10	8.40	33.9	25.8	27.4	28.6	31.2	34.5	38.9	22.2	23.8
12	10.2	42.6	32.4	34.4	35.9	39.2	43.3	48.8	27.9	29.9
15	12.7	53.2	40.4	43.0	44.9	49.0	54.2	61.0	34.9	37.4
18	15.3	63.9	48.5	51.6	53.9	58.8	65.0	73.2	41.9	44.8
21	17.0	67.8	51.5	54.7	57.2	62.4	69.0	77.7	44.4	47.6
24	19.5	79.1	60.1	63.9	66.7	72.8	80.5	90.7	51.9	55.5
27	22.0	89.5	68.0	72.3	75.5	82.4	91.1	103	58.7	62.8
30	24.4	99.7	75.8	80.5	84.1	91.8	101	114	65.4	70.0
33	27.5	111	84.2	89.5	93.5	102	113	127	72.7	77.8
36	29.0	120	90.8	96.5	101	110	122	137	78.4	83.9
39	31.5	130	99.1	105	110	120	133	149	85.5	91.5
42	34.0	141	107	114	119	130	144	162	92.6	99.1
45	36.5	152	116	123	128	140	155	174	99.7	107
48	39.0	163	124	132	137	150	166	187	107	114
54	42.0	176	134	142	148	162	179	202	115	124
60	48.0	198	150	160	167	182	201	227	130	139



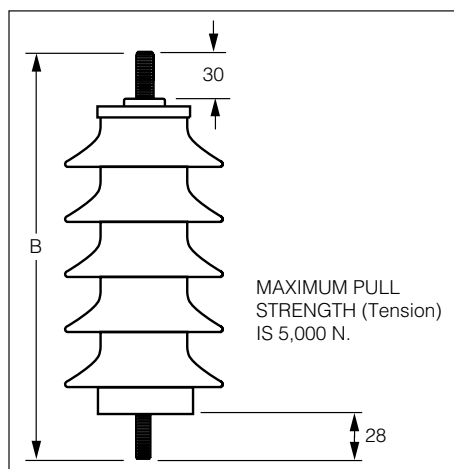
## DIMENSIONS AND MOUNTING

Figure 4 illustrates an in-line mounting arrangement; the applicable values of "B" and "C" may be found in Table 5. Line and Earth terminal details are shown on Page 7, options 11 and 12. Figure 5 shows an outline drawing of the standard UltraSIL housed VariSTAR Class 1 arrester. The values for dimension "A" for all ratings are listed in Table 5.

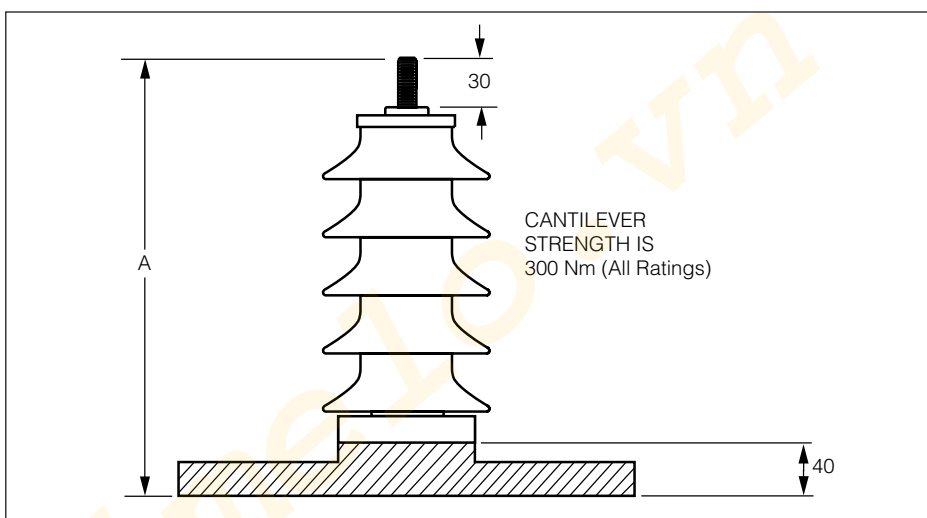


**Figure 4.**  
Three-phase in-line mounting.

Note: Refer to Table 5 for Dimensions B and C.



**Figure 5.**  
UltraSIL housed arrester for base or cable riser mounting (arrester may be horizontal or vertical with either end at line potential).



**Figure 5a.**  
UltraSIL housed arrester with pedestal mounting base.

**Table 5**  
Catalog Numbers and Dimensional Information and Weights for VariSTAR UHS Surge Arresters

Arrester Rating (kV, rms)	Arrester COV (kV, rms)	Catalog Number	Dim. A (mm)	Dim. B (mm)	Dimension C Minimum Phase-to-Earth Clearance* (mm)	Dimension D Minimum Phase-to-Phase Clearance* (mm)	Housing Leakage Distance (mm)	Arrester Mass (kg)
3	2.55	UHS0303	158	146	76	108	183	3.2
6	5.10	UHS0604	186	174	102	140	256	3.4
9	7.65	UHS0905	214	202	133	178	330	3.6
10	8.40	UHS1005	214	202	133	178	404	3.6
12	10.2	UHS1206	242	230	152	197	477	4.5
15	12.7	UHS1507	267	255	171	222	551	5.0
18	15.3	UHS1808	295	283	235	286	625	5.2
21	17.0	UHS2109	320	308	235	286	698	5.4
24	19.5	UHS2410	348	336	273	337	772	5.6
27	22.0	UHS2711	376	364	273	337	846	5.9
30	24.4	UHS3012	402	390	273	337	919	6.1
33	27.5	UHS3313	430	418	324	413	993	6.4
36	29.0	UHS3614	458	446	324	413	1067	6.6
39	31.5	UHS3915	483	471	398	538	1140	6.8
42	34.0	UHS4216	511	499	418	562	1214	7.7
45	36.5	UHS4518	567	555	442	587	1288	8.2
48	39.0	UHS4818	567	555	470	614	1361	8.4
54	42.0	UHS5421	651	639	500	645	1435	8.6
60	48.0	UHS6021	651	639	558	703	1509	9.2

Notes:

1. Cantilever strength for all ratings is 300 Nm.
2. Refer to Figure 4 for illustrations of minimum spacing dimensions C and D and Figure 5 and 5a for dimensions A and B.

\* Phase-to-Phase clearances are expressed as minimum arrester center-to-center distances. Phase-to-Earth clearances are expressed as minimum arrester centerline-to-ground distances.

**TABLE 6**  
**UltraQUIK™ Catalog Numbering System for UltraSIL™ Housed VariSTAR Class 2 Arresters**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
U	H	S												1

**Catalog Number Digits:**

1 - 3= "UHS" (UltraSIL Housed Class 1 Surge Arrester)

**4 and 5 = Arrester Rating: Duty-cycle (COV)**

**03** = 3 kV (2.55 kV)    **15** = 15 kV (12.7 kV)    **30** = 30 kV (24.4 kV)    **45** = 45 kV (36.0 kV)  
**06** = 6 kV (5.10 kV)    **18** = 18 kV (15.3 kV)    **33** = 33 kV (27.0 kV)    **48** = 48 kV (39.0 kV)  
**09** = 9 kV (7.65 kV)    **21** = 21 kV (17.0 kV)    **36** = 36 kV (29.0 kV)    **54** = 54 kV (42.0 kV)  
**10** = 10 kV (8.4 kV)    **24** = 24 kV (19.5 kV)    **39** = 39 kV (31.5 kV)    **60** = 60 kV (48.0 kV)  
**12** = 12 kV (10.2 kV)    **27** = 27 kV (22.0 kV)    **42** = 42 kV (34.0 kV)

6 & 7 = Housing Code (Select from Table below):

**AVAILABLE HOUSINGS BY ARRESTER RATING**

★ = Standard Housing

○ = Housing Options

U <sub>r</sub> Arrester Rating (kV rms)	Digits 6 & 7	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
	Leakage Length (mm)	183	256	330	404	477	551	625	698	772	846	919	993	1067	1140	1214	1288	1361	1435	1509
3	*		○*																	
6				○	○															
9			○*	○	○	○	○													
10			*	○	○	○	○													
12				*	○	○	○	○	○	○										
15					*	○	○	○	○	○	○									
18							*	○	○	○	○	○	○							
21								*	○	○	○	○	○							
24									*	○	○	○	○							
27										*	○	○	○	○	○	○	○	○	○	○
30											*	○	○	○	○	○	○	○	○	○
33												*	○	○	○	○	○	○	○	○
36													*	○	○	○	○	○	○	○
39														*	○	○	○	○	○	○
42															*	○	○	○	○	○
45																	*	○	○	○
48																	*	○	○	○
54																		*	○	○
60																			*	○

**8 = Line Stud and Lead Options:**

- 12 mm Line Terminal Options – all threaded studs are 12 mm x 30 mm long (except options L and M), stainless steel.

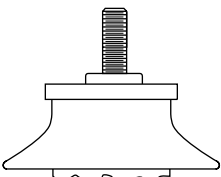
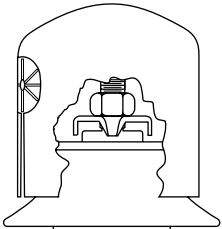
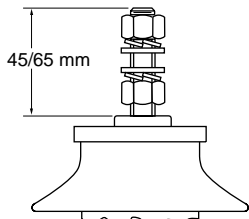
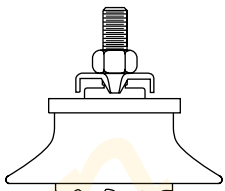
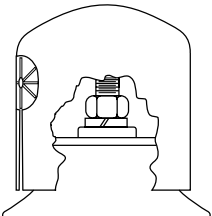
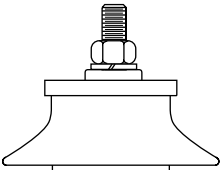
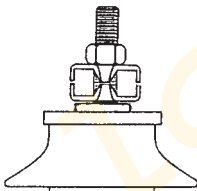
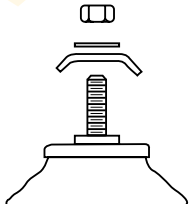
**A** = with 30 mm long stud,  
12 mm Diameter

**L** = with 45 mm long stud,  
12 mm Diameter

**M** = with 65 mm long stud,  
12 mm Diameter

**9 = Line Terminal Accessories**

All line terminal accessory hardware is stainless steel 12 mm Ø, as required

 <p><b>C</b> = No Hardware</p>	 <p><b>F</b> = Nut, Wire Clamp &amp; Universal Wildlife Protector</p>	 <p><b>L</b> = 2 each: Nuts, Flat Washers &amp; Lock Washers (Requires "L" or "M" in Digit 8)</p>	 <p><b>R</b> = Nut &amp; Wire Clamp</p>
 <p><b>S</b> = Nut, Lock Washer &amp; Universal Wildlife Protector (Also for leads with ring terminals, see Digit 8)</p>	 <p><b>T</b> = Nut, Lock Washer (Also for leads with ring terminals, see Digit 8)</p>	 <p><b>U</b> = Nut &amp; 2 Wire Clamps</p>	 <p><b>V</b> = Wire clamp, Nut, &amp; Flat Washer</p>

Notes:

1. Wire clamps F R & U will accommodate #10 solid to 2/0 AWG or to 4 mm solid diameter wire. Wire clamp V will accommodate 6 mm solid or up to 14 mm diameter stranded conductor.
2. Maximum allowable torque on line terminal is 27 Nm.
3. The universal wildlife protector may only be used with 30 mm or 1-3/16" length stud.

**10 = Stainless Steel Ground Terminal Stud**

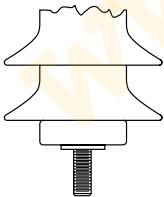
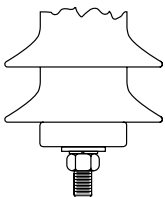
**A** = 12 mm Ø x 30 mm long

**B** = 12 mm Ø x 45 mm long

**C** = 12 mm Ø x 65 mm long

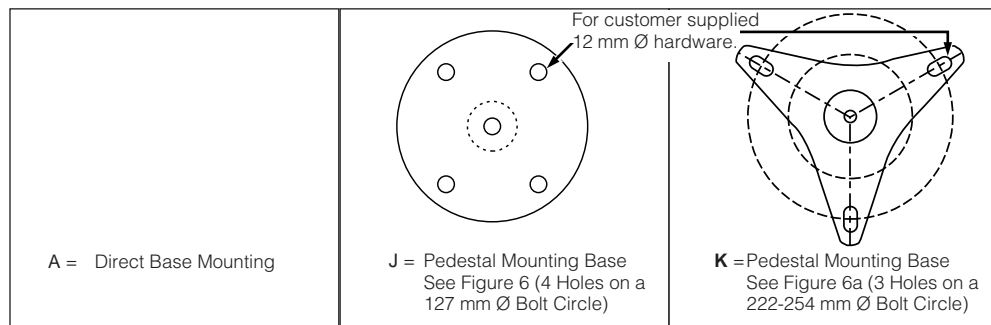
**J** = Required for option K in digit 13

**11 = Ground Terminal Hardware**

 <p><b>B</b> = No Hardware (Required for option J in digit 13)</p>	 <p><b>W</b> = Washer Lock Washer, and Nut</p>	<p><b>4</b> = Required for option K in digit 13</p>
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**12 = Area Mounting**  
**0 Base Mounted**

**13 = Mounting Options**



**14 = Nameplate Information, See Figures 7 and 7a**

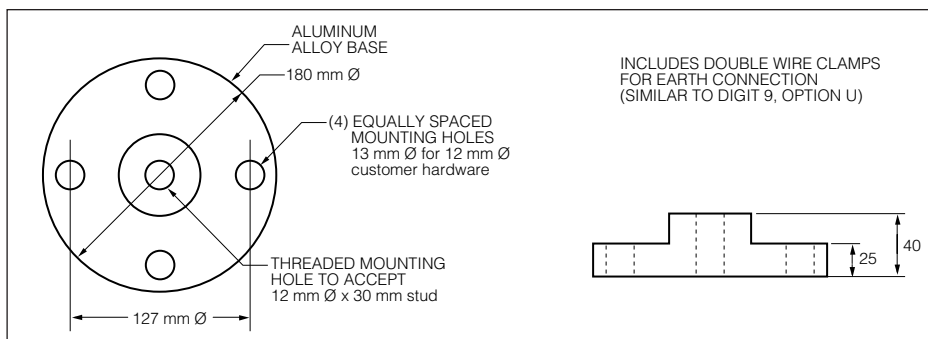
Nameplate information is per IEC 60099-4 (IEC 99-4). Auxiliary nameplates are available in the following languages:

- A = English
- B = Español – Mexico
- C = Español – Americas
- D = Português – Americas
- E = Español – Europa
- F = Português – Europa
- G = Polski
- H = Français

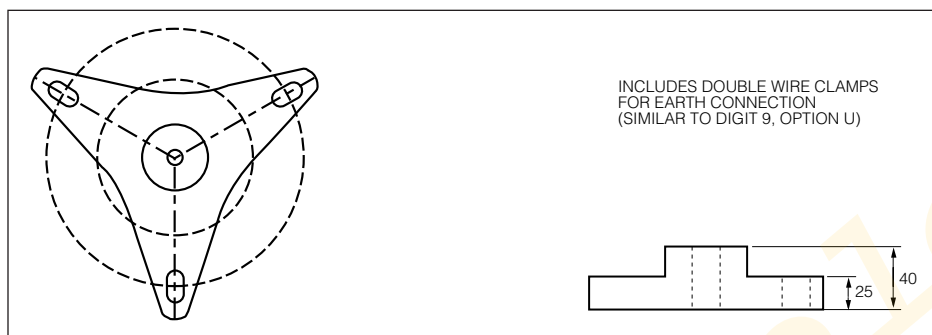
**15 = Packaging**

- 1 = Individual carton. Each arrester with accessories is shipped in an individual cardboard carton. Individual cartons are packed within a heavy duty (quad-wall carton having a skid bottom and suitable for double stacking within a shipping container).



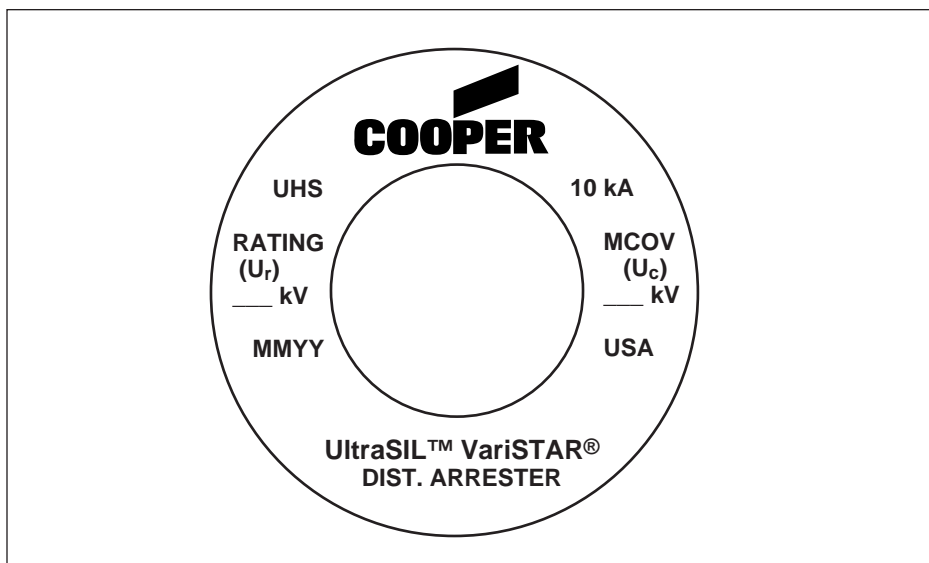


**Figure 6.**  
Pedestal mounting base for all ratings.



**Figure 6a.**  
Pedestal mounting base for all ratings.

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**Figure 7.**  
 **$I_N = 10$  kA, UHS UltraSIL Nameplate – stamped in stainless steel top cap.**

<p>VARISTAR® SURGE ARRESTER                      ULTRASIL™ TYPE UHS-ZnO  <math>I_N = 10</math> kA CLASS 1 IEC 60099-4 P.R. = 20 kA sym</p> <p>(ENGLISH)</p>	<p>PARARRAYOS VARISTAR®                      TIPO ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASE 1 CEI 99-4 AdP = 20 kA sim</p> <p>(ESPAÑOL - EUROPA)</p>
<p>APARTARRAYOS VARISTAR®                      TIPO ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASE 1 IEC 60099-4 AdP = 20 kA sim</p> <p>(ESPAÑOL - MEXICO)</p>	<p>DESC. DE SOBRET. VARISTAR®                      TIPO ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASSE 1 IEC 60099-4 LdeS = 20 kA sim</p> <p>(PORTUGUÊS - EUROPA)</p>
<p>PARARRAYOS VARISTAR®                      TIPO ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASE 1 IEC 60099-4 AdP = 20 kA sim</p> <p>(ESPAÑOL - AMERICAS)</p>	<p>OGRANICZNIK PRZEPIEC VARISTAR®                      ULTRASIL™ TYP UHS-ZnO  <math>I_N = 10</math> kA KLASA 1 IEC 60099-4 Pr = 20 kA sym</p> <p>(POLSKI )</p>
<p>PÁRA-RAIOS VARISTAR®                      TIPO ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASSE 1 IEC 60099-4 Sp = 20 kA sim</p> <p>(PORTUGUÊS - AMERICAS)</p>	<p>PARAFOUDRE VARISTAR®                      MODELÉ ULTRASIL™ UHS-ZnO  <math>I_N = 10</math> kA CLASSE 1 IEC 60099-4 LdP = 20 kA sym</p> <p>(FRANÇAIS)</p>

**Figure 7a.**  
 **$I_N = 10$  kA, Class 1, UHS UltraSIL Arrester Auxiliary Nameplates.**

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